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COMMERCIAL ONION GROWING

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SUMMARY

1. Onions are grown very extensively on the muck soils of northern Indiana, the crop of 1914 amounting to 2,210,325 bushels.
2. Good drainage is an important factor in selecting muck soil for profitable onion growing.
3. Thorough preparation of the soil before planting is especially important in onion growing, many growers preferring to prepare the land in the fall. Rolling is of great value on the muck soil.
4. Potash is the element most deficient in the non-acid muck soils, and muriate of potash applied at the rate of 200 to 400 pounds per acre will give a very profitable increase in yield with normal prices.
5. Acid phosphate at the rate of 300 to 400 pounds per acre can usually be applied profitably to the muck soil for onions. The acid muck soils are especially deficient in phosphorus, and larger amounts should be applied to these soils.
6. Nitrate fertilizers can seldom be applied with profit to the muck soils.
7. Lime can not be applied with profit except to the acid muck soils.
8. Manure is the best all around fertilizer for onions, but under normal conditions chemical fertilizers can be applied most economically to the muck soils. The manure should be well rotted.
9. Onion seed should be sown in rows 12 to 14 inches apart at the rate of three and one-half to four pounds per acre as early in the spring as the ground can be worked.

10. Frequent cultivation with wheel hoes, and two or three hand weedings are necessary in growing onions successfully.

11. The onions are harvested about September 1. The best growers average over 500 bushels per acre, which sell at an average of 40 cents per bushel. It costs about \$75.00 to produce an acre of onions.

12. A large part of the Indiana onion crop is stored.

13. Onion sets and pickling onions are grown extensively in Lake county. The culture is similar to that of large onions, except that the small onions are produced by thick seeding.

14. Onion seed is grown successfully by some of the large growers of Indiana.

15. There are three serious insect pests of onions, namely, thrips, maggots, and cut worms, all of which can be controlled successfully.

16. Onion mildew is the most serious disease and can be controlled by spraying with Bordeaux mixture.

FOREWORD

This circular describes the most successful practice in the commercial production of onions on the muck lands of northern Indiana. It is the result of observations, correspondence, and special field studies carried on by the writer during the summers of 1915 and 1916, supplemented by observations made by Mr. W. E. Lommel during the summer of 1915. The growers in the principal onion producing regions of the State were visited, and their problems and methods studied. The work was carried on under the direction of the Horticultural Division of the Department of Agricultural Extension. Acknowledgment is due to Mr. S. D. Conner of the Soils and Crops Department of the Experiment Station for special information regarding fertilizers.

INTRODUCTION

That the onion growing industry is thoroughly established as one of the important agricultural enterprises of the State is shown by the fact that Indiana ranks fourth in the United States in onion production. According to the Bureau of Crop Estimates of the United States Department of Agriculture, there were 6801 acres devoted to onions in 1914 in Indiana, which produced 2,210,325 bushels or an average yield of 325 bushels per acre for the entire state. The quality and quantity of the Indiana onion crop has attracted the attention of produce dealers throughout the country. Consequently many traveling buyers come to the Indiana fields in harvesting time, and compete with local dealers, thus stimulating the demand for Indiana onions.

The great bulk of the Indiana onion crop is produced in the two northern tiers of counties, the following counties leading in onion production in the order named: Starke, Noble, Whitley, St. Joseph, LaPorte, Marshall, Kosciusko, DeKalb, Steuben and Lake. There are considerable areas of muck soils in these counties, and this soil and climate seem especially well adapted to onion growing.

Since the production of ripe onions from seed is of the greatest importance in this state, this phase of the onion industry will receive the principal attention in this circular, and will be discussed with considerable detail.

SOILS

While onions may be grown profitably on many types of soil, larger and more economical yields are produced on the peat, or as they are commonly called "muck" soils throughout the northern part of the State. Onions require unusually fertile soil containing an abundance of organic matter as well as a liberal supply of inorganic plant foods, in order to produce the most satisfactory yields. Therefore, the rich muck soils when intelligently fertilized, furnish ideal growing conditions for this crop. The muck soils are some of the richest soils in the State, being composed of 35 per cent. to 80 per cent. of organic matter and an unusually high percentage (1 to 3) of nitrogen and when properly fertilized, so as to make up any deficiency in the inorganic plant food materials, they will produce enormous yields of onions under normal conditions.

CHARACTERISTICS OF THE MUCK SOILS

The muck soils are black or dark brown in color, very loose and spongy in texture with great water absorbing capacity. They are composed largely of decayed and partially decayed vegetable matter which grew in the bottom or around the margins of lakes and swamps, centuries ago. When this land was drained, these deposits were left, sometimes in small "pockets" and also in large areas, such as the great "Kankakee marsh" region. The muck deposits vary in depth from a few inches in some cases to twenty feet or more in other regions. Naturally these muck areas are very level and in many cases they are low and poorly drained. Good drainage is absolutely essential in onion growing and is therefore one of the most important considerations in choosing a location for onions. The water table should be at least two feet below the surface of the ground and water should never stand on the onion land, especially when the crop is in the ground. The best muck for onions is that which is 18 inches or more in depth and underlaid with marl, and is non-acid in reaction.

One difficulty frequently encountered in onion growing due to the peculiar loose texture of the muck soil, is the "blowing out" of the crop by the wind. Unless the muck soil is thoroughly packed, a strong wind is liable to blow out the seeds or small seedlings so that this feature must be considered in the preparation of the soil.

DRAINAGE

The first consideration in preparing the land for onions is thorough drainage, and on muck soils this frequently necessitates the use of tile drains. Onions require considerable moisture early in the season, although they will quickly turn yellow and die if the soil remains water logged for any extended period. The land must be drained sufficiently, either by ditches or tile so that the excess water will be carried off rapidly. Late in the summer when the onions are maturing and the tops drying, the onions will mature better and be of superior keeping quality if the soil is fairly dry, because a moist soil at this time will tend to keep the tops green, which will result in a large proportion of "thick necks" and onions of poor keeping quality.

SUBDUING NEW MUCK

It is not desirable to grow onions on muck land the first year it has been cultivated, because onions require very thorough preparation of the soil, and new muck will contain many weed seeds, and tough sods which would seriously interfere with the cultivation of the crop with wheel hoes. For a year or two, the new land should be planted to potatoes or corn or some other crop requiring cultivation and which can be cultivated with horse tools. This will put the land in much better condition for onions and is the most economical method of getting the land in suitable shape for growing onions and other crops requiring a great deal of hand labor.

PREPARATION OF THE MUCK SOIL FOR ONIONS

Thorough preparation of the soil is of great importance in onion growing, yet many growers prepare their fields carelessly or inadequately, with the result that the subsequent care and expense of growing the crop are greatly increased. Poor stands are often due to this cause. The importance of careful preparation of the soil can scarcely be over emphasized. A good seed bed is the primary requisite for the best development of the seedlings, and the more thoroughly a field is prepared with horse tools, before planting, the less trouble and expense will be involved in cultivating the crop with hand tools.

In preparing the soil for onions, plowing is the first consideration. The muck should be plowed deeply and the surface soil,

with its growth of weeds, turned under completely. Many of the best growers practice fall preparation of the muck soil for onions, in order to have the soil in a firmer, more compact condition in the spring and thus reduce the danger of the onions being blown out of the loose soil by the high winds.

When the land for onions is prepared in the fall it should be worked as late as possible before freezing weather. The soil should be plowed deeply, and then thoroughly disced. It should be disced at least once in each direction, and as many more times as necessary to cut up all clods and put the soil in fine condition. It should then be harrowed with a spike-toothed harrow or dragged with a planker to leave a smooth level surface, after which it should be rolled with a heavy roller to pack the soil particles thoroughly and to make a smooth seed bed. This is one of the most important operations in growing onions on muck soils because of the extremely loose texture of this type of soil. One advantage of fall preparation of the soil is, that the muck is firmer at this time; consequently, heavier rollers can be used than when the muck is softer in the spring. Many of the larger growers use heavy traction engines for preparing the ground in the fall and in addition, roll the soil with five-ton rollers. Prepared in this way, the muck land will be much firmer at planting time and there will be less danger of the seeds or seedlings being blown out by the wind. Another advantage of the fall preparation is that it saves time and relieves the rush of work in the spring.

After such fall preparation the only treatment necessary before planting is to harrow the soil, apply and harrow in fertilizers, and roll the seed bed again. Owing to the soft condition of the muck in the spring, it is generally necessary to use horse drawn rollers of lighter weight than can be used in the fall. After rolling, it may be necessary to go over the soil with a drag or planker, to smooth away irregularities and fill in the horses' hoof prints, in order to leave a perfectly smooth level surface to facilitate planting with a garden seed drill.

When the onion land is prepared in the spring, the operations are much the same. It should be plowed deeply, thoroughly disced, the fertilizers applied and harrowed in, planked, and then the ground should be thoroughly rolled with a heavy roller. It may also be necessary as mentioned before to finish off with a drag or planker to smooth off all irregularities which would tend to interfere with the best operation of the seed drill.

FERTILIZERS

In order to secure the largest and most economical yields of onions, it is necessary to apply additional plant food to the soil. The kind of fertilizers to use and the amount which can be applied with profit depend upon the character of the soil.

In general, the muck soils of Indiana may be divided into two main types, namely, acid muck and non-acid muck. As a rule the non-acid muck soils are fairly well supplied with phosphorus, but are very deficient in potash, while the acid muck soils sometimes contain a fair percentage of potash but are very deficient in phosphorus. All muck soils are abundantly supplied with nitrogen and organic matter.

The acid muck is less desirable for onions and requires a greater outlay for fertilizers than the non-acid muck, but fortunately the greater part of the muck soils in the northern part of Indiana are non-acid.

Summarizing the results secured to date from the cooperative demonstrations with onions being carried on in Indiana, and also the eight different experiments with onions on muck soil reported in Bulletin No. 157, and comparing these results with commercial practice, the following conclusions are drawn regarding fertilizers for onions on muck soil.

POTASH

Muck soils are as a rule deficient in potash and in all of these experiments the application of potash greatly increased the yield of onions, and when this element can be obtained at normal prices, a liberal quantity of potash fertilizer may be applied at a decided profit. In one comparison of muriate and sulphate of potash the muriate gave much larger yields indicating that muriate is the best form in which to apply this element, especially since it is the cheaper fertilizer. The exact amount of this fertilizer that can be applied with profit depends upon the price secured for the onions and the cost of the fertilizer, but under normal conditions 200 to 400 pounds of muriate of potash per acre, or an equivalent amount of potash in some other form, can be applied to the onions each year with profit.

PHOSPHORUS

Experiments show that the application of phosphorus to the muck soils also increases the yield of onions and on most muck soils a phosphate fertilizer can be applied with profit. The amount of phosphorus needed, depends upon the character of the muck. The acid muck soils are generally very deficient in phosphorus and on soils of this type 800 to 1000 pounds of acid phosphate per acre may be applied with profit the first year and 500 to 600 pounds per acre in succeeding years. The non-acid mucks, the type which predominates in the northern part of the State, are as a rule, fairly well supplied with phosphorus, but experiments have shown that the application of phosphate fertilizers increased the yield of onions and that a moderate amount of phosphate could be applied with profit. Consequently, on the non-acid muck soils an application

each year of 300 to 400 pounds of acid phosphate per acre is recommended. In addition to increasing the yield, acid phosphate tends to hasten maturity and produce firmer onions of superior keeping quality.

In a comparison of acid phosphate, ground bone, and raw rock phosphate, to determine the best form of applying phosphorus, the acid phosphate gave the largest and most economical increase in yield, and since this phosphate is immediately available to the plants, it proved to be the best form of applying phosphorus to onions and other truck crops.

NITROGEN

The muck soils contain a large percentage of nitrogen, much of which is available, especially as the season advances and the nitrifying bacteria become active. Consequently, nitrate fertilizers are unnecessary as a general rule on the muck soils. This has been borne out in the experiments in which nitrate of soda and tankage were applied to the muck soil. Neither of these nitrate fertilizers gave a profitable increase in yield. Therefore, under ordinary circumstances the application of nitrate fertilizers is not advisable. However, in a cold backward spring when nitrification in the soil is delayed, a moderate amount of nitrate of soda may be applied with profit. Nitrate of soda is immediately available and the application of 100 pounds per acre early in the season may stimulate the seedlings into a vigorous growth and thus increase the yield. Nitrate fertilizers which are not immediately available should never be applied, neither should nitrate of soda be applied late in the season because at this time nitrification will be proceeding rapidly and the muck soil will be abundantly supplied with available nitrogen and an excess of this element would stimulate leaf growth and interfere with the proper maturity of the bulbs, increasing the number of "thick necks" and making the onions soft and of poor keeping quality.

LIME

On the acid muck soil, lime is absolutely necessary to make it productive and large quantities of ground limestone should be applied. However, on the non-acid muck soil, lime is unnecessary to correct acidity, and in the cooperative demonstration work before mentioned, lime at the rate of one ton of ground limestone per acre on non-acid muck, not only failed to give a profitable increase in yield, but even decreased the yield in some cases. Consequently, unless the soil is acid, the application of limestone is not advisable.

MANURE

Large increases in yields have been secured from the application of fifteen tons of well rotted manure per acre. However, a

study of the results shows that the manure gave very little increase where potash was also applied, indicating that the principal benefit from the manure was undoubtedly due to the potash it contained. Since the muck soils contain a very large percentage of organic matter and nitrogen (the fertility factors for which manure is chiefly valued) it is evident that manure is unnecessary from this standpoint, and the results indicate that when chemical fertilizers, especially potash, can be secured at normal prices, they will prove the most economical fertilizers for the muck soils. Whether manure or chemical fertilizers will be cheaper, must be determined by local conditions, such as cost of manure, distance of hauling, etc. One great objection to the use of manure is that it introduces weed seeds unless the manure is well rotted before it is applied to the soil, and thus increases the expense of weeding.

In order to get the greatest benefit from manure, it should either be applied to the soil immediately, or composted in such a way that the plant foods will not be leached away. Composting or rotting the manure overcomes the objection of introducing weed seed previously mentioned. Furthermore, it reduces the bulk of the coarse material to be worked into the soil, which is of considerable importance in the loose muck soil and permits a more thorough incorporation of the manure with the soil.

On the other hand, if the manure is composted in the open ground as is frequently done by thoughtless farmers, most of the element which is most needed from the manure, namely potash, is leached out. However, if the manure is ricked in flat piles about four feet deep on a concrete floor with a low curbing around to hold the water, all of the soluble plant foods in the manure can be saved, and the manure will rot quickly and can be best prepared in this way for application to the soil.

METHODS OF APPLYING FERTILIZERS

Uniformity of distribution, timeliness of application, and the correct depths to work them into the soil, are the important factors in applying fertilizers.

When chemical fertilizers are applied, they should be harrowed into the soil in the spring after it has been plowed, disced, harrowed and rolled. After harrowing in the fertilizers, the soil should be rolled again to get it firm and smooth before sowing the seed. The chemical fertilizers may either be sown broadcast by hand, or they may be applied with a fertilizer spreader. Lime may be applied in the spring or fall and should be harrowed into the soil the same as the chemical fertilizers. The best results are secured when half of the chemical fertilizer is applied under the rows where it will be immediately available to the young seedlings at the time it is most needed. The balance of the fertilizer should be applied broadcast

between the rows. The fertilizer under the row will give the seedlings a good start and stimulate a vigorous growth, while the broadcasted fertilizer will tend to promote a more branching root system, which will support the plant later in the season. Since the onion roots do not spread greatly, a large proportion of the fertilizer can be reached by the roots when it is applied under the row. However, too heavy an application under the row will tend to bunch the root system and interfere with the best development of the plant later in the season.

When manure is used, it may be applied in the fall or in the spring. Fresh manure, that is, manure that has not been rotted should be applied preferably in the fall and plowed or disced under at that time so that it will become thoroughly incorporated with the soil before the seed is sown.

Well rotted manure may be applied either in fall or in the spring. In either case, the soil should first be plowed and disced and then the manure should be applied and worked into the soil with a disc. Following this, the soil should be harrowed and rolled as mentioned before.

SOWING THE SEED

After the ground has been thoroughly prepared and fertilized, the seed should be sown. This should be done as early as the ground is in good condition, that is, dry enough and firm enough to be



Fig. 1. Sowing onions with garden seed drills

worked, and preferably the first or second week in April. Onions require a cool, moist season for their early development, and warm, dry weather at the time the bulbs are maturing. For this reason

they should be planted early so that they will get a good start in the cool, moist weather in early spring so that they will mature in August or early in September, when the season is normally warm and dry and before the fall rains occur which interfere with the proper ripening and keeping quality of the onions. Fall plowed land can generally be planted earlier than spring plowed land which is another advantage of fall preparation of the soil.

The seed is usually sown as shown in Fig. 1, with a garden seed drill which sows one row at a time, but on some farms where a large acreage of onions is planted annually, a gang drill is used which sows six rows at once. The distance between rows varies from 12 to 14 inches, depending upon the personal preference of the growers. The narrower distance will usually produce a slightly larger yield per acre, but requires more care and expense in cultivating and gives a larger percentage of small onions, so that the majority of growers plant the rows 13 inches apart. The rate of seeding, that is, the amount of seed sown per acre, is a most important factor, and one in which there is considerable difference of opinion among growers. The rate of seeding depends somewhat upon the distance between rows, that is, more seed is required where the rows are 12 inches apart than where the rows are 14 inches apart.

The general practice when the rows are 13 inches apart, is to sow four to four and one-half pounds per acre while others sow six pounds per acre. Some of the most successful growers who average unusually large yields every year sow only three and one-half pounds of seed per acre.

Because of the large amount of hand labor necessary and the additional expense, it is not profitable to thin the onions on muck land. Consequently the rate of seeding should be such that the desired stand can be secured without thinning. If too much seed is sown, the onions will be crowded and small, while if too little seed is used, the yield will be reduced.

When the soil has been properly prepared and fertilized three and one-half to four pounds of good seed will under normal conditions and good cultivation, produce large, well developed bulbs, and the total yield of marketable onions will be as great as when more seed is used, because heavier seeding will result in crowding the plants too much and producing more undersized bulbs.

This brings up the question of good seed, a factor which can hardly be over emphasized. Without good seed, the preparation of the soil, cultivation, etc., are in vain and growers should exercise great care in buying seed, and plant only the best, for inferior seed means a poor stand, lack of uniformity and onions of inferior quality.

Onion seed soon loses its viability and growers should take pains to get new seed each year. The germination of the seed should also be tested and only seed which shows a high percentage of germination (80 to 85 per cent.) should be sown. Some of the large growers find it profitable and desirable to grow their own seed, thus insuring by careful selection, good, strong seed that will produce onions of superior quality and uniformity. The method of growing onion seed will be discussed subsequently.

VARIETIES

The variety of onions to be grown depends upon the purpose for which the onions are to be used, (that is, early use or storage) and upon the demand of the market. The great bulk of the onions grown on the Indiana muck soils are for fall and winter use, and for this purpose the yellow globe type is the most commonly grown, although the red globe varieties are also very popular. The white varieties are grown principally for pickling.

Of the yellow globe type there are several varieties which are commonly grown. The Southport yellow globe is by far the most popular yellow variety, while the Ohio yellow globe and yellow globe Danvers are grown to a lesser extent. Of the red varieties, the Southport red globe is most popular, and the Red Wethersfield, and Ohio red globe are also grown. Of the white varieties, the Southport white globe is the most popular for large, mature white onions, while the white Portugal and Silver Skin are popular varieties for pickling onions.

It is especially important that the seed be true to type and variety.

CULTIVATION OF ONIONS

As soon as the row of seedlings can be seen, cultivation of the onions should begin. This is important for two reasons, first to destroy all weeds, when they are small and most easily killed, and second to establish a mulch on the surface soil and thus conserve the soil moisture. If the soil has been rolled as it should have been, this will pack the soil, and favor the rapid rise of capillary moisture to the surface, and it is especially important that a surface mulch be created as soon as possible in order to hold this moisture in the soil.

Cultivation with a wheel hoe should be continued throughout the season until the onions get so large as to be injured by the wheel hoe. A thorough cultivation with the hand cultivator should be given every ten or twelve days, making a total of six to ten cultivations in a season. The cultivation should be shallow, because onions are shallow rooting plants, therefore the side hoe attachment for the hand cultivators are most commonly used. When the onions are small, a two wheel cultivator which straddles the row as shown in Fig 2, is generally considered the most satisfactory implement, while later on, when the tops are large, a single wheel cultivator which goes between the rows will give better results. The straighter the rows have been seeded, the easier and more rapidly they may be cultivated and the fewer plants will be injured or torn out by the cultivator.



Fig. 2. Double wheel hoe for use early in the season. By skillful use of this implement much hand weeding may be avoided

HAND WEEDING

Although frequent cultivation with wheel hoes will eradicate most of the weeds, many weeds will spring up in the rows and thus be protected from the cultivator. These weeds must be pulled by hand, for they grow so rank on the muck land that they would soon ruin or greatly reduce the onion crop. (see Fig. 3.) At least two hand weedings will be necessary and in some seasons the onions will

have to be hand weeded three or four times in order to keep the fields clean and permit the best growth of the onions. The weeding should not be delayed too long, for the small weeds can be



Fig. 3. When hand weeding has been too long deferred the onions will be disturbed and the large weeds will make cultivation difficult



Fig. 4. It pays to keep the onion field well cultivated and free from weeds

pulled much easier and with much less disturbance of the onions than when the weeds have become larger and well rooted. It is economy to keep the field clear of weeds as shown in Fig. 4, because the weeds will interfere seriously with cultivation, will overshadow and crowd out the onions, and greatly reduce the yield.

In the onion districts most of the hand weeding is done by boys and girls who can be hired for ten cents per hour. They are usually hired in large gangs as shown in Fig. 5, with a foreman to keep them busy, and will clean up a field in a short time. It costs from three to four dollars an acre for each hand weeding.



Fig. 5. The first hand weeding. Active boys make the best help for this work

HARVESTING ONIONS

The onions should mature and be ready to harvest in August or early September. When properly matured the tops will shrivel, dry up at the neck and fall over. The onions should be harvested promptly when this occurs. When the tops do not show a tendency to shrivel at the neck but begin to dry at the tips, some growers drag a light plank over the tops or use some other means of breaking them, to induce them to dry at the neck, but onions which do not mature in this way naturally are seldom of good keeping quality.

There are two principal methods of harvesting and curing onions. The great bulk of the Indiana onion crop is cured in the fields, but the white varieties must be cured in open sheds and many growers use this method of curing the yellow and red varieties as well.

When cured in the field, six rows are pulled and laid in a windrow, as shown in Fig. 6. In pulling the onions, three rows are pulled on each side and they are laid in the windrows so that the tops partially cover the bulbs to protect them from the sun. They are left in the windrows from four days to two weeks, depending



Fig. 6. Gathering up the onions after being cured in the field

upon the weather. If rain should occur while the onions are in the field they should be turned with a scoop fork or wooden rake so that they will dry thoroughly.

As soon as the tops are thoroughly dried, the onions should be gathered up in crates. Slatted crates holding a bushel are used for this purpose. The method of crating depends upon how the onions are to be topped. If topped by hand, the onions are gathered by the handful and the tops are either cut off with sheep shears or twisted off, allowing the topped onions to fall into the crate.

When the onions are to be topped by machine, they are gathered from the field by means of large slatted scoops or scoop forks and dumped into the crates and hauled to the topping machine. This machine tops the onions and also grades them, the No. 1 onions being delivered at one end and the No. 2 onions, those under one and one-fourth inches, being delivered at one side.

When the onions are topped by hand, they must later be graded and sorted. This is done by passing them over a slatted rack, with the slats one and one-fourth inches apart. As they are passed over the sorting rack the "thick-necks" and other inferior onions are removed by hand, while the small onions and dirt drop through the slats.

After grading, the onions are bagged, if they are to be sold immediately or they are put into the slatted bushel crates for storage. They are usually left in the crates in the open sheds until freezing weather, when they are put in frost proof storage houses.

White onions can not be cured in the fields as above described because they would turn green or become sunburned and discolored, which would greatly reduce their quality and market value. Therefore, they must be cured in crates in open sheds. Many growers prefer this method for curing the yellow and red onions also, claiming that the onions are brighter and of better color and keeping quality when cured in this way, which may be described as follows:

When topped by machine, the white onions are pulled early in the morning and laid in windrows as previously described, but instead of leaving them in the field for a few days, they are gathered up into crates about nine or ten o'clock in the morning and taken to the topping machine immediately.

When a topping machine is not used, the onions are topped as they are pulled, that is, as a handful of onions is pulled, the tops are twisted off and the bulbs dropped into a crate.



Fig. 7. Shallow crates used for curing onions. Note slatted bottoms and cleats on corners to facilitate ventilation

After being topped, the onions are put into slatted crates which are stacked in open sheds, so that they will be protected from sun and rain, but so that the air can circulate through them freely. Some growers use the ordinary bushel crate for curing the onions in this way, while others use a more shallow crate or tray. The crates are not filled completely, so that when the crates are stacked there will be an air space between the onions in one crate and the bottom of the crate above. When the shallow trays are used, an

inch cleat is nailed to each corner as shown in Fig. 7, in order to leave an air space between the crates. Narrow aisles are left between the tiers of crates to permit free circulation of the air and facilitate handling the onions.

The onions are left in these open curing sheds until marketed or until freezing weather, when they must be put into the storage houses.

MARKETING ONIONS

The magnitude of the Indiana onion crop has attracted the attention of produce dealers throughout the country and many of the larger firms send their buyers to the principal onion districts in the State during the harvesting season. A large part of the crop is marketed through these traveling buyers. In addition, there are local dealers and brokers, and warehouse men who buy a considerable proportion of the crop. Many of the onion growers, however, prefer to sell through commission dealers in the various cities throughout the country. Some of the larger growers act as their own selling agents, and market their crops direct to produce dealers and wholesalers in the smaller cities along the railroads passing through their shipping point. Different markets prefer different kinds of onions. White onions sell to the best advantage in New York and other eastern markets; while the yellow globe, and to a lesser extent the red globe varieties, are preferred in the central western markets, although the red onions will generally bring the best prices in the southern markets. Some growers sell at harvesting time; others store their crop and speculate on getting higher prices during the winter or spring.

The price of onions is extremely variable, sometimes ranging from 25 cents to \$2.00 per bushel in a single season. The price is determined by the storage quality of the crop and by the condition and magnitude of the crop in the onion producing regions throughout the country.

The onions are usually marketed in one-hundred-pound sacks. Storing the crop in the hope of securing higher prices later in the season, offers the usual speculative advantages and disadvantages, and in some seasons, will yield a good profit while in other seasons it will result in loss. A higher price must be secured for the stored crop, because storing necessitates an extra handling of the crop, and an extra storage charge besides a certain amount of loss in storage due to shrinkage and to onions of poor keeping qualities.

STORING ONIONS

Onions are rather exacting in their storage requirements and these conditions should be observed closely if the onions are to be kept for any length of time. Onions will keep best in a cool, fairly dry atmosphere, with good circulation of air. A warm temperature

and moist atmosphere will cause the onions to sprout or rot in storage, while freezing will cause the onions to break down and rot quickly when thawed out unless thawed very gradually. Consequently, the onions are commonly stored in frost proof storage houses, similar to the one shown in Fig. 8. The onions are stored in slatted crates, and the houses are equipped with ventilators in the roof and near the ground so as to permit good circulation of air. The walls are carefully insulated by means of several thicknesses of boards and heavy paper with dead air spaces between, in order to make the houses as nearly frost proof as possible. During very

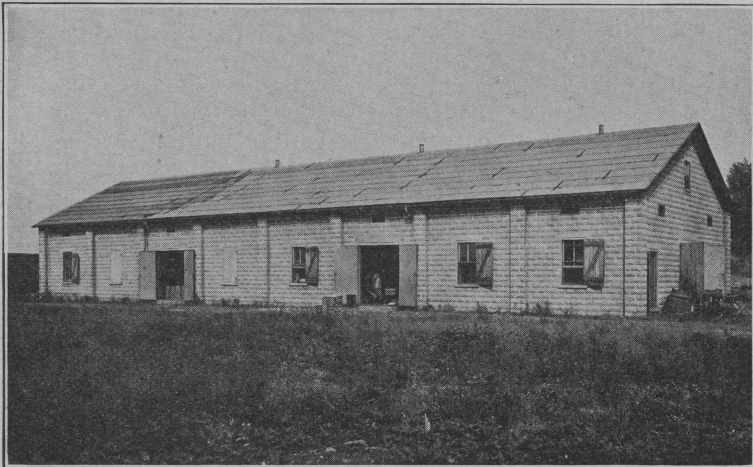


Fig. 8. Frost proof onion storage house showing facilities for good ventilation

cold weather, oil stoves are used in the houses to keep the temperature above the freezing point. The more uniform the temperature, the better the onions will keep, and a temperature of 40 degrees to 45 degrees should be maintained if possible.

The charge for storage is usually ten to fifteen cents per bushel for the season. The losses in storage depend upon the attention that is given to the proper ventilation and temperature of the storage house and also upon whether the onions have been properly ripened and matured and are free from disease. When given good care, there is only a slight loss in storage, although in some cases the loss amounts to 50 per cent. or more. If rot appears in storage, the loss can be greatly reduced if the onions are carefully sorted and the diseased ones promptly thrown out.

Some of the small growers, especially in the vicinity of Hammond, Indiana, store their onions very successfully in storage pits constructed as follows:

A slatted rack is made three and one-half to four feet wide and forty to fifty feet long and with sides six inches high. The rack is then placed over a dead furrow which has previously been plowed in a well drained location. This dead furrow or air passage permits free circulation of air under the slatted rack. The onions are then heaped on this rack, thus making a long, narrow oval-topped pile. The onions are then covered with about a foot of clean straw, and boards or branches are laid on to hold the straw. As the weather becomes colder, the straw is covered with four inches of soil; then in very cold weather another foot of straw is put on and another four inch layer of soil. The ends of the air passages are also plugged in very cold weather. The onions will keep better in this pit if stored with the tops on, and may be kept very successfully in this way until February or later.

RETURNS FROM ONIONS

The yields and the net returns from onions vary considerably with the season, and with the individual growers. In 1914, the average yield for the entire State of Indiana was 325 bushels per acre, while some of the best growers have averaged over 500 bushels per acre for a number of years. The average price secured has been 40 cents per bushel although the price varies greatly.

It costs from \$75.00 to \$90.00 per acre to grow onions, including the rent of the land and all the operations connected with producing the crop. Some growers have estimated that it costs them from 17 to 25 cents per bushel to grow the onions, although this is a very uncertain figure.

ROTATIONS

Onions are one of the exceptional crops in which an annual rotation is not always advisable. It costs so much to get the land in good condition for onions and to keep it free from weeds, that unless diseases or insects appear which are liable to live over in the soil each year, it is generally advisable to plant onions in the same ground for a number of years without rotation, providing it is properly fertilized. Some growers who have a very loose soil, rotate their onions with sod every three or four years, claiming that the grass roots will tend to hold the soil particles and reduce the danger of the onions being blown out by the wind. Other growers rotate the onions with potatoes, and cabbage, or other cultivated crop which will tend to keep down the weeds.

GROWING ONION SETS

In one locality in Indiana, namely in Lake county, in the vicinity of Hammond, the growing of onion sets is an important industry. Onion sets are matured miniature onions, which have

been unable to grow to normal size because of a restricted food supply. In the commercial production of onion sets, the food supply is limited by very thick seeding. The subsequent competition between the large number of seedlings limits the food supply of each seedling and thus restricts the growth of the individual bulbs and causes them to ripen and mature while very small.

PREPARATION OF THE SOIL

In the vicinity of Hammond where the onion set industry has reached its highest development in Indiana, the soil used for growing onions is a clay loam. Manure from the Chicago Stock Yards is the only fertilizer used by the growers in this region. The manure is applied in the fall at the rate of a car load per acre, every year, or in some cases every second year. The region is quite level and in order to facilitate drainage and hasten the drying off of the soil in the spring, it is usually plowed in the fall. The manure is turned under at this time and the ground is plowed in long narrow beds or "lands" twelve to fifteen feet wide and two hundred feet or more in length.

In the spring as early as the ground can be worked, it is disced thoroughly and harrowed and then dragged with a plunker to break up all clods and make a fine, smooth seed bed. Since this soil is rather heavy and tenacious it should not be rolled, as is necessary on the muck soils.

SOWING THE SEED

The essential difference between the production of onion sets and the production of large onions is in the rate of seeding, the dense seeding being depended upon to check the growth of the onions for sets. In the growing of large onions three to five pounds of seed are sown to the acre, while for the production of onion sets, 50 pounds to 80 pounds of seed are sown per acre, the usual practice being to sow 60 to 65 pounds. The seed is sown in rows 12 inches apart using a garden seed drill, many growers using a special attachment on the drill which will spread the seed slightly in the row, thus producing a broad band instead of a single row of seedlings. The seed should be sown as early as the ground can be worked in the spring, generally early in April.

Thorough cultivation is necessary the same as for the production of large onions, but in the narrow aisles between the rows of onion sets, only the narrow, one-wheel cultivators can be used, and for the last one or two cultivations, a scuffle hoe is generally used, as it will disturb the onions less than a wheel hoe. Generally, five or six cultivations are given with a wheel hoe at intervals of about ten days.

In addition, about three hand weedings will be required in order to remove the weeds in the rows. This hand weeding is very tedious and expensive, but is necessary for the production of a good crop. The weeding is generally done by boys and girls from nearby towns.

HARVESTING ONION SETS

Onion sets mature earlier than large onions, usually being ready to harvest in July or early August. In harvesting, the onions are first loosened by means of an onion harvester, an attachment for the wheel hoe which runs under the row and loosens the soil. The onions are then pulled and dropped into bushel baskets. Topping is unnecessary as the tops are generally so small as to be negligible. Any large tops may be twisted off as the onions are pulled. The harvesting is done principally by women and children as shown in Fig. 9. They are paid at the rate of seven cents per bushel for pulling the onions. The sets are then dumped into shallow, slatted



Fig. 9. Harvesting onion sets

crates, which are spread in the field for a day or stood on edge as shown in the background of Fig. 9, to thoroughly dry the sets. After being cured in this way for a day the sets are screened through a three-eighths inch screen as shown in Fig. 10. This removes all dirt and undersized sets. The screened sets are then placed in the shallow crates or trays again and the trays are stacked in the field, one above the other to cure. The stacks are usually six feet high. A shutter is then placed over the top of the stacks to shed water, or the crates may be stacked in open sheds. These crates are four feet long, thirty inches wide and four inches deep and have slatted bottoms. Across each corner is nailed a one inch cleat as shown

in Fig. 7, so that when the crates are filled with onions and stacked one above the other, there will be an air space between each crate, through which the air can circulate and thus facilitate curing the onions. They are left in these curing crates until freezing weather when they are again screened, and all over one inch in diameter removed and the balance put in storage.



Fig. 10. Screening and grading onion sets

MARKETING ONION SETS

Most of the growers of onion sets contract for the sale of their crop in advance of planting. They are sold principally to seed firms, produce dealers and wholesalers, although some are sold through commission dealers. The average contracted price for the last year was 90 cents per bushel. The yield of onion sets averages about 350 bushels per acre.

ONIONS FOR PICKLING

Onions for pickling are grown much the same as onions for sets, except that slightly larger onions are desired, and consequently less seed is sown per acre. Also, only the white varieties are grown for pickling, while the yellow and red varieties, as well as the white varieties are grown for sets.

The seed for pickling onions is sown at the rate of about 25 pounds per acre, and the onions are harvested and cured the same as described for onion sets, except that they are graded differently.

No. 1 onions for pickling are between one-half inch and one inch in diameter. Therefore at the time the onions are harvested they are screened through a one-half inch screen, and placed in the curing crates as described for onion sets. In the fall, after being thoroughly cured, they are fanned and screened through a one inch screen.

Pickling onions are usually sold by contract in advance of planting and the buyer usually pays 60 cents per bushel for the No. 1 pickling onions, that is between one-half inch and one inch in diameter, and one cent per pound for the onions over one inch in diameter. The yield of No. 1, pickling onions, averages about 450 bushels per acre.

GROWING ONION SEED

While onion seed is not grown commercially to any great extent in Indiana, some of the best growers find it a very good practice to grow their own seed and can usually dispose of the surplus at a very good profit.

Careful selection of the mother bulbs and care in curing and storing the seed are the most important factors in producing high



Fig. 11. Planting selected bulbs for growing onion seed

grade onion seed. By producing his own seed, the grower is sure of having fresh, viable seed each year, and by practicing rigid selection, a superior strain can soon be developed.

The selection of the mother bulbs can be made during the sorting and grading of the crop. Great care should be exercised to select the bulbs which are as uniform as possible and of the ideal shape, size, color and quality. The bulbs should be stored over winter in the usual way, or they may be planted in the early fall and will survive the winter without protection. When planted in the spring, they should be set out as early as the ground can be prepared. On a soil which is very rich in nitrogen, the blossoms are more likely to drop off without setting fruit; consequently muck soil is not as desirable as a moderately fertile loam soil for growing seed. However, good seed can be produced on the muck soil. The soil for growing onion seed should be well fertilized with potash and phosphorus fertilizers as these elements play an important part in seed production.

The soil should be thoroughly prepared and then rows should be furrowed out three feet apart and four to six inches deep as shown in Fig. 11. The selected bulbs should be planted in the bottom of this furrow, setting the bulbs firmly in an upright position



Fig. 12. A fine crop of onion seed ready to be harvested

and from four to six inches apart in the row. They are given good cultivation throughout the season, and as the seed stalks develop they are usually supported by lines of wire or by piling up the soil around them.

As the seed heads turn yellow and ripen as shown in Fig. 12, they should be harvested by cutting them from the seed stalk below the head. They should then be spread on a cloth in the sun to dry for a couple of days. The heads are then taken up and spread in a thin layer on the floor of a well ventilated barn or crib until thoroughly dried, when they may be flailed or threshed.

The seed is cleaned after threshing by running it through a fanning mill. The poor seed and chaff is then separated by pouring the seed into a tub or tank of water. The good seed will sink to the bottom, while the light seed and chaff will float and can be removed by skimming. The seed must then be spread out on cloths in the sun until dry and should then be spread thinly in a dry, well ventilated crib or loft until thoroughly dried, when it should be stored in a cool, dry place.

INSECTS AND DISEASES

There are three insect pests, namely: thrips, maggots, and cut worms, which sometimes cause considerable loss to the onion growers in northern Indiana.

The onion thrips cause considerable damage every year, especially in dry seasons. This minute insect chafes off the epidermis of the leaves, causing yellowish, gray irregular spots to appear on the leaves, later causing the entire leaf to dry up, turn yellow and die. These insects work principally at the base of the leaves and for that reason are difficult to reach with a spray material. However, they may be controlled by spraying if it is done thoroughly. As commonly practiced by the commercial grower, the spraying is not very effective because of the failure to get the spray material down into the sheaf, as the majority of these insects will be found at the base of the leaves and will escape unless the spray reaches them. In order to spray onion thrips successfully, two things are necessary, namely, high pressure (at least 100 pounds) and a good spray nozzle which will produce a fine mist-like spray which can be directed into the base of the onion leaves. The great difficulty in spraying onions is in getting a spray outfit which will go between the onion rows without damaging the plants and at the same time maintain sufficient pressure. The knapsack sprayer and wheel barrow traction sprayers are most convenient in getting between the rows, but are not satisfactory because sufficient pressure cannot be maintained. A gasoline outfit or good hand pump outfit equipped with a long line of hose and extension rod is the most satisfactory type of outfit that has been used thus far. With the spray outfit at the end of the rows, the long lead of hose can be carried or dragged between the rows while the operator sprays the onions on each side as far as he can reach with the extension rod. There is need of great improvement in onion spraying machinery.

For onion thrips the following spray material will destroy the insects if hit by the solution, but it must be borne in mind that this spray material must come in actual contact with the insect in order to be effective, hence the necessity of spraying thoroughly and getting the solution down into the sheaf of the onion.

Formula

Concentrated nicotine sulphate.....	5 ounces
Whale oil soap.....	4 pounds
Water	50 gallons

The nicotine sulphate is a commercial preparation that may be obtained at most drug stores and dealers in spray materials. The soap can best be dissolved by slicing it into water. The nicotine sulphate can then be added and stirred thoroughly.

The spray should be applied when the thrips first appear and the onions are small and easily sprayed. It will probably have to be repeated two or three times at intervals of ten days in order to destroy succeeding generations as they hatch. If thoroughly applied this insect can be controlled very successfully with this spray.

Maggots

Onion maggots sometimes ruin whole fields of onions and cause more or less damage every year throughout the onion regions. The adult form of this maggot is a fly somewhat similar to the common housefly but considerably smaller. This fly lays its eggs in the sheath of the onion at the surface of the ground when the plants are very small. These eggs hatch in about ten days and the maggots burrow into the bulbs or roots of the onion, causing the loss of the plant. Where the maggots are prevalent, whole fields are ruined. A second and sometimes a third brood appears later in the season. Field hygiene is especially important in controlling onion maggots. The removal and burning of infested plants are especially important. All refuse from crop, and trash should be removed from the field and burned at the end of the season.

A new method of control devised at the Wisconsin Experiment Station, is claimed to give excellent results in controlling this pest. This treatment called the "poison bait spray," destroys the fly which lays the eggs. It is used as follows: as soon as the onion seedlings appear, the first spray should be applied, and it should be repeated at intervals of five days or a week during the period when the flies are present.

The spray consists of one ounce of sodium arsenite, two and one-half quarts of New Orleans molasses and five gallons of water. The arsenite should be dissolved in boiling water and the molasses added and thoroughly mixed. In applying this spray, a whisk broom may be used, or it may be applied with a spray outfit using a

coarse nozzle, as this poisoned bait should be applied in coarse drops along the rows so that the flies can drink it instead of as a fine mist to cover the plants.

After onions have become infested with maggots, there is nothing that will remedy the difficulty that season, but infested plants should promptly be removed and burned in order to reduce the number of insects that will appear the following season, and then the poisoned bait should be applied in time to destroy the flies before they have an opportunity to lay their eggs.

CUTWORMS

Occasionally cutworms cause considerable loss in the onion fields. These worms cut off the young plants at the surface of the ground, the damage being noticeable immediately, and if serious, control measures should be undertaken at once. Cutworms can be very successfully controlled by the use of poisoned bait prepared as follows:

Mix 50 pounds of wheat bran or middlings, two pounds of Paris green and six finely chopped oranges or lemons. Then add enough cheap molasses and a little water to make a stiff dough. Scatter lumps of this mixture about the size of a marble around the infested areas. Cutworms feed principally at night, so it is best to distribute the poisoned bait in the late afternoon so that it will not be dried out before the cutworms commence to feed.

DISEASES

As a general rule the onion growers in northern Indiana have suffered comparatively little loss from diseases of onions.

The onion mildew has been serious in some cases especially in damp weather. This disease appears in late June or July and is first noticed on the outer leaves, which become pale, and collapse and have a somewhat violet color. The tips of the other leaves also show symptoms of the disease and in severe cases the whole top dies, thus producing a small inferior onion. This disease may be controlled successfully by spraying the plants thoroughly with Bordeaux mixture. The spraying outfit described for controlling onion thrips may be used, or a knapsack sprayer or wheel barrow, traction sprayer will be satisfactory for this work.

Warm, moist weather favors the development of this disease and a thorough spraying with Bordeaux mixture (four pounds quicklime, four pounds copper sulphate, and 50 gallons of water) should be given at the first signs of the disease. This will usually suffice, although it may be necessary to repeat the spray at intervals of ten days.

